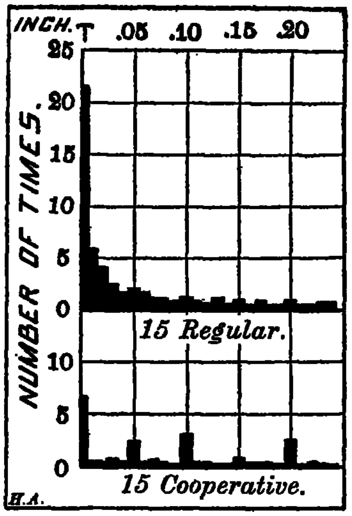

FIG. 15. Average frequency curves for daily rainfalls, April to September, 1914, as recorded at 15 regular Weather Bureau stations and at 15 cooperative stations. (See table below.)

Summary of daily rainfalls recorded in figure 15.

	Trace.	0.01 to 0.24	0.25 to 0.99	1.00 +
At 15 regular stations	322	487	240	70
At 15 cooperative stations	102	246	280	90
Coop. / Regular.	32%	51%	117%	129%

TABLE 5.—*Average number of days with 0.01 inch or more of precipitation in Wisconsin.*

[From Summary of Climatological Data for Sections 58, 59, 60.]

Station.	Length of record.	Number of rainy days.	Station.	Length of record.	Number of rainy days.
	Years.	*Days.*		*Years.*	*Days.*
Ashland	16	78	Prentice	11	86
Barron	16	75	Stevens Point	17	78
Butternut	13	81	Valley Junction	18	89
Downing	15	73	Viroqua	19	100
Duluth	**39**	**131**	Wausau	14	102
Eau Claire	19	86	Amherst	16	81
Grantsburg	17	70	Appleton	10	108
Hayward	19	86	Beloit	17	77
Osceola	17	79	Brodhead	11	94
Red Wing	9	79	Chilton	15	101
Spooner	13	68	Crandon	11	70
Wabasha	14	88	Delavan	13	81
Weyerhauser	7	84	Florence	17	78
Whitehall	15	77	Fond du Lac	17	93
Dodgeville	10	78	**Green Bay**	**23**	**124**
Dubuque	**36**	**116**	Lake Mills	17	111
Grand Rapids	11	84	Madison *	31	111
Hancock	18	89	Manitowoc	17	98
Hatfield	12	69	**Milwaukee**	**39**	**128**
Hillsboro	19	76	New London	14	80
Koepenick	18	99	Oconto	18	96
La Crosse	**37**	**117**	Oshkosh	16	71
Lancaster	18	83	Pine River	15	94
Mauston	14	88	Port Washington	16	80
Meadow Valley	19	86	Racine	14	89
Medford	19	66	Shawano	13	88
Neillsville	21	56	Sheboygan	10	94
Portage	14	81	Watertown	18	100
Prairie du Chien	22	88	Waupaca	14	88

* 26 years cooperative, 5 years regular station.

The great differences between the records of stations manned by professional observers and those made by amateurs may be reduced to some extent by considering only the same period, but they are mainly due to differences in the fidelity to duty, as may be easily shown. This suggests the possibility of classifying observers with respect to fidelity to duty by arranging them in the order of the total number of rainy days reported by them.

The table, or curve, of frequency distribution of daily rainfall, however, gives a valuable insight into the observer's habits of work; its use can not well be omitted by working climatologists or the directors of climatological services without danger of loss of valuable time and effort in dealing with worthless or vitiated data.

REMARKS.

Prof. John F. Hayford, director of the College of Engineering, Evanston, Ill., presents by request the following comments on the above paper:

EVANSTON, ILL., *May 17, 1915.*

The use of the daily rainfall frequency distribution as a test for errors in the manner indicated in Mr. Miller's paper, seems to me to furnish interesting and suggestive indications of the habits of the observer and the character of the errors in the record turned in by him.

The value of these indications depends primarily upon the use which is made of them. Two general classes of use may be considered: (1) They may be used as a means of inspection of the observer and his work; and (2) they may be used as a guide in testing the accuracy of cooperative rainfall observations and as indicating how to reach safe conclusions from them.

If your observers would take suggestions kindly and seriously, if having found a cooperative observer's observations considerably in error it were possible to replace him by some one else, and if a considerable amount of inspection of a cooperative observer's work were possible, the indications obtained from the frequency-distribution tests advocated by Mr. Miller would be of considerable value as a part of inspection. * * *

As a guide in testing the accuracy of cooperative rainfall observations and as indicating how to reach safe conclusions from them, it seems to me that the frequency-distribution tests are likely to prove valuable if carefully considered and applied. In my opinion, the necessarily careful consideration involves traveling farther along Mr. Miller's line of thought than he has yet gone, judging by his paper. It may lead in some cases to added confidence in the records rather than the reverse. The following paragraph is, possibly, a fair example of a reason for increased confidence based on frequency-distribution tests.

Consider the "Summary of daily rainfalls" under figure 15. This summary indicates that the cooperative observers missed 220 "Traces" (322−102) which may be estimated as 0.005 inch each, or a total of 1.1 inch; and 241 rainfalls between 0.01 and 0.24 inch (487−246), which may be estimated at 0.12 inch each, or a total of 28.9 inches. The total loss thus established *in these two groups is*, therefore, 1.1+28.9=30 inches. This is less than 10 per cent of the total shown in Table 2. This evidence indicates, therefore, that the total precipitation lost from the record in the form of smaller rainfalls which are unrecognized or erroneously recorded by the cooperative observers as a group, is possibly less than 10 per cent and almost certainly less than 20 per cent of the total amount. Are not other errors, in part unavoidable, probably larger than this? For example, is not the error in the total rainfall for a region produced by peculiarities in the geographical distribution of the stations and in the location with reference to the topography frequently much greater than 10 per cent? Will not any reduction in the number of cooperative stations tend strongly to increase the errors referred to in the preceding sentence?

The errors in the recorded total precipitation produced by the mere habit of concentrating the readings at 0.05, 0.10, 0.15, etc., are probably less than 5 per cent, and possibly less than 1 per cent—too small to be of importance. I reached this conclusion from a hasty study of Tables 1 and 2 and figure 15.

It seems to me that Mr. Miller's reasoning is conclusive in showing that the number of rainy days per year has one significance for regular stations and quite a different significance for cooperative stations.—*John F. Hayford.*

THE HOTTEST REGION IN THE UNITED STATES.

By G. H. WILLSON, District Forecaster.

(Dated: Weather Bureau, San Francisco, Cal., July 5, 1915.)

When the gold seekers and pioneers came to California in the early fifties many of them crossed the deserts in the southeastern portion of the State, and the intense heat experienced in that region during the summer months soon became well known and much feared. The sufferings of both man and beast while traveling over those dreary wastes have been the subject of many interesting papers, some of which were based upon facts while others were pure fiction. Undoubtedly many lives have been lost in that region, and while the extreme heat has probably taken its toll, by far the greater number have perished from thirst.

It has long been believed that the hottest place in this country was in one of those depressions below sea level in southeastern California, Death Valley or the Salton Sea country. Until June, 1911, there was only a short record from Death Valley, but there were many long and reliable records from the latter which showed extremely high temperatures; therefore the Salton Sea country was generally considered to be the hottest place in the United States. It will surprise many persons to learn that not only the highest temperature in this country occurred in Death Valley, but that the highest shade temperature ever recorded in the open air with standard instruments and under approved methods of exposure in any portion of the world was recorded at Greenland ranch, on the edge of Death Valley, Inyo County, Cal., on July 10, 1913, when the thermometer registered 134° F. In fact, the record from this station for the period from July 8 to 14, 1913, inclusive, is probably the most remarkable authentic record of high shade temperatures ever made. The daily maxima during this intensely hot spell were: 8th, 128°F.; 9th, 129°; 10th, 134°; 11th, 129°; 12th, 130°; 13th, 131°; and 14th, 127°. During this time the temperature never fell below 85°F.

In the spring of 1911 arrangements were made between the United States Weather Bureau and the Pacific Coast Borax Co. to establish and maintain a Weather Bureau cooperative station at their place known as Greenland ranch, on the edge of Death Valley. This ranch is located on Furnace Creek at the eastern edge of Death Valley and 178 feet below sea level, but somewhat higher than the main floor of the valley. The ranch embraces about 100 acres of irrigated land on which alfalfa and some fruit and vegetables are grown. The meteorological equipment is that usually furnished to cooperative stations; it consists of Weather Bureau standard maximum and minimum thermometers, a raingage and a thermometer shelter. The shelter is of the regulation pattern, with louvered sides, a tight floor, and a double roof. The shelter is painted white with several coatings of white lead. The location for the instruments was carefully selected, the shelter being placed over an alfalfa sod, the floor about 4 feet above the ground, the shelter door facing north and about 50 feet from the nearest high object. The location is such that *the shelter is not exposed to the reflected heat from the desert.*

Evaporation is excessive in this section and liberal irrigation is necessary to maintain plant life; hence, the cooling by evaporation from the surrounding damp ground and live vegetation is probably sufficient to lower the readings of the instruments several degrees. Undoubtedly the temperature down in the desert bottom of the valley is much higher than it is at Greenland ranch.

The maximum thermometer in use during the hot weather of July, 1913, was graduated up to 135° F. only, and in a note accompanying his report at the close of the month, the observer stated that he doubted if the record was sufficiently high because other ordinary thermometers at the ranch showed a much higher temperature.

In order that the true value of this record may be appreciated, the following statement kindly furnished by Prof. C. F. Talman, Librarian, U. S. Weather Bureau, of other high temperatures reported in different portions of the world is submitted for comparison:

Greely's American Weather, page 128, mentions a temperature of 127.4° F. on August 27, 1884, at Ouargla (better spelled Wargla), on the edge of the Sahara desert, as "probably the highest registered by a trained observer from a reliable, well-exposed thermometer." This maximum has been repeated in meteorological works, down to the present time, as the highest well-authenticated temperature heretofore observed. However, Greely also (p. 129) mentions a temperature of 128°F. at Mammoth Tank, Cal., July, 1887, and this is also sometimes cited as the "record" for the world. Hann's Handbuch der Klimatologie (3d ed., vol. 3, p. 485) mentions a temperature of 131° F. (55°C.) as having been observed by the traveler, Stuart, in the interior of New South Wales, in January, 1845. In Thomson's "Introduction to Meteorology," p. 56, a temperature of 132°F. is said to have occurred near the Euphrates; while the Encyclopædia Britannica (9th ed., vol. 30, p. 810) states that 167°F., in the shade, has been observed in the desert of Gobi. I know of no other authority for this last extraordinary temperature record. In any case, the temperature of 134°F. at Greenland ranch remains the highest recorded for any definite station.

It appears strange that Gen. Greely should give the record of 128°F. in July, 1887, at Mammoth Tank, Cal., as the highest, when the records of that station show 130°F. on August 17, 1885, as stated in Weather Bureau Bulletin L. The old station at Volcano Springs, now under the waters of Salton Sea, has a record of 129°F. on June 23, 1902, and of 128°F. on July 5, 1905. This latter record was reached on a Weather Bureau standard maximum thermometer exposed in a standard shelter.

The temperature records at Greenland ranch now cover a period of four years, from June, 1911, to May, 1915, inclusive. Temperatures reaching 100°F. or more may be expected from April to October, inclusive; reaching the highest point in July or August. Temperatures of 120°F. or more have been recorded in May, June, July, and August. Temperatures of 80°F. or more have been recorded in all months, and of 90°F. or more from February to November, inclusive. The mean of the monthly maximum temperatures has exceeded 100°F. from May to September, inclusive, every year with one exception, when the record was 95.4° F. The average daily maximum temperature exceeded 110°F. twice in four times in June, and in every July and August; the greatest being 117° F. in July, 1911. In the months of July and August, for the four years under discussion, the mean daily maximum temperature has exceeded 115°F. three times in each month, the exceptions being 110.7°F. in July, 1912, and 111.4°F. in August of the same year.

The lowest temperature recorded was 15°F. on January 8, 1913. This low temperature occurred during a spell of exceptionally cold weather in California, when many long records of low temperature were broken in all portions of the State. Minimum temperatures of 32°F. or below have been recorded in November, December, January, and February. The mean daily minimum temperatures have been below 32°F. for but two months during the four years' record: January, 1913, when it was 26.5°F., and December, 1912, when it was 30°F. The mean monthly minimum temperature for July and August has exceeded 80°F., except in August, 1911 (78.9°F.), and July, 1912 (79.6°F.). The mean monthly temperature has exceeded 100°F. half of the time in both July and August; it has exceeded 90°F. in every June and for half of the time in September. The highest monthly mean temperature was 101.6°F. in July, 1914, and the lowest was 45.8°F. in January, 1913.

The maximum temperature has reached or exceeded 100°F. on 548 days in the four years from June, 1911, to May, 1915, inclusive, as follows: in April 15 times, May 72, June 108, July 123, August 124, September 97, and October 9 times; and reached or exceeded 120°F. on 59 days, as follows: May 2, June 5, July 25, and August 27 days.

The daily weather maps have been carefully studied for some peculiarity that would explain the extremely hot weather in Death Valley in July, 1913, but it is doubtful if a sufficient cause was found.[1] The weather type

[1] *Compare* Notes on the climate and meteorology of Death Valley, Cal., by Mark W. Harrington. Washington, 1892. 50 p. 8°. (Weather Bureau Bull. 1.)

was that which always causes high temperatures over the south Pacific coast district, it was not unusually pronounced, and did not give record temperatures in any other portion of California. The wind along the eastern slope of the Sierra was very light and from the north, causing a slow southward movement of the air from the high plateau and mountain regions of northern Nevada. As it was descending it was heated dynamically in passing down the western slopes of the Amargosa and Funeral Mountains to the deep valley below. Once in the valley the surface air probably became stagnant owing to the high walls at the south end, and was heated rapidly by the reflected heat from the rocks and desert floor of the valley.

The condition was probably local as is often the case in mountainous regions, and the exceptionally high temperatures were confined to Death Valley.

The following tables present the temperature records of this hottest station, by years and months:

TABLE 1.—*Temperatures recorded by Weather Bureau thermometers in a standard shelter at Greenland ranch, Inyo County, Cal.*

[Lat. 36° 27′ N.; long. 116° 50′ W. Alt., −178 feet, M. S. L.]

HIGHEST TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1911	....	....	....	....	....	120	122	122	118	100	90	80	122
1912	85	88	91	98	120	120	118	120	112	99	87	82	120
1913	82	90	98	109	120	119	134	124	116	105	90	74	134
1914	73	85	98	104	116	124	122	126	112	101	91	82	126
1915	76	75	92	101	113	....	....	....	....	....	....	....	....
Monthly extremes	85	90	98	109	120	124	134	126	118	105	91	82	134

LOWEST TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1911	....	....	....	....	....	63	72	69	60	51	27	22	22
1912	22	33	38	36	55	57	67	68	56	42	32	21	21
1913	15	30	36	47	52	60	70	74	66	60	58	52	15
1914	52	47	52	50	53	60	76	70	60	68	57	52	47
1915	50	43	45	56	52	....	....	....	....	....	....	....	....
Monthly extremes	15	30	36	36	52	57	67	68	56	42	27	21	15

MEAN TEMPERATURE.

[½(mean max.+mean min.)]

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1911	....	....	....	....	....	93.8	100.2	97.2	87.6	72.8	59.6	51.6	....
1912	53.0	60.0	65.5	71.6	82.4	90.2	95.2	96.0	83.2	71.9	50.1	48.8	73.8
1913	45.8	57.3	63.2	77.2	84.8	92.4	98.6	100.4	92.6	82.4	72.4	61.8	77.4
1914	65.2	67.3	73.4	75.4	85.8	91.4	101.6	100.4	90.0	81.9	72.6	66.2	80.9
1915	64.6	61.8	69.8	78.1	80.4	....	....	....	....	....	....	....	....
Means	57.2	61.6	68.0	75.6	83.4	92.0	98.9	98.5	88.4	77.2	65.9	57.1	77.0

MEAN MAXIMUM TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1911	....	....	....	....	....	111.9	117.0	115.6	105.2	91.0	78.1	68.9	....
1912	72.7	80.6	81.5	88.7	100.0	109.5	110.7	111.4	100.9	88.4	78.9	67.7	....
1913	65.1	72.7	81.4	96.2	103.4	110.0	116.4	116.5	107.4	94.6	78.6	65.7	....
1914	68.8	75.1	86.3	88.5	100.2	106.9	116.6	116.2	109.0	91.5	81.5	72.9	....
1915	69.8	69.0	82.6	91.4	95.4	....	....	....	....	....	....	....	....
Means	69.1	74.4	83.0	91.2	99.8	109.6	115.2	114.9	105.6	91.4	79.3	68.8	91.9

MEAN MINIMUM TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1911	....	....	....	....	....	75.7	83.5	78.9	70.1	54.7	41.2	34.3	....
1912	33.2	39.3	49.5	54.5	64.8	71.0	79.6	80.7	65.4	55.4	39.3	30.0	....
1913	26.5	41.0	44.9	58.2	66.2	74.9	80.8	84.4	77.7	70.2	66.2	57.8	....
1914	61.5	59.5	60.6	62.3	71.3	76.0	86.5	84.5	70.9	72.3	63.7	59.4	....
1915	59.3	54.6	57.0	64.8	65.3	....	....	....	....	....	....	....	....
Means	45.1	48.8	53.0	60.0	66.9	74.4	82.6	82.1	71.0	63.2	52.6	45.4	62.1

SUMMER TEMPERATURES AT PARIS AND AT RENO, NEV.

By H. F. ALCIATORE, Section Director.

[Dated: Weather Bureau, Reno, Nev., May 26, 1915.]

In connection with Angot's method for classifying summers (Monthly Weather Review, Nov., 1914, **42**: 628–629) I here submit a tabulated statement of temperature excesses (on a basis of 30°C. or 86°F.), differences, and departures for Reno, Nev., and Paris, France. Angot has stated that his method gives results to a certain extent dependent upon the temperature selected for the lower or starting point. As the only Paris data at hand are those for summers compared on a basis of 30° C., I selected the same temperature for comparing Reno's summers. It is evident that a starting temperature of 86°F. (30°C.) is too low for Reno, the average excess for the summer being 177°F. as against 27°F. at Paris.

In a way, the starting temperature, if judiciously chosen, could be such as to give one a fairly good idea of what might be called the "discomfort units" of summer. For example, at Reno (and probably at 99 per cent of the regular Weather Bureau stations) a day on which the temperature exceeds 90°F. (32.2°C.), would be termed a warm day, while one with 87°F. (30.6°C.) would not.

TABLE 1.—*Reno and Paris summers compared.*

(Reno: Lat., 39° 32′ N.; long., 119° 49′ W.; elevation, 4,500 feet above sea level.)

[Sums of maximum temperatures exceeding 86°F.]

Year.	At Reno—						Sum, Reno.	Sum, Paris.	Difference, Paris-Reno.	Departures at—	
	Apr.	May.	June.	July.	Aug.	Sept.				Paris.	Reno.
1888	2	....	....	46	84	26	158	9.0	−149.0	− 21.3	− 19
1889	....	6	38	99	98	23	264	1.1	−262.9	− 29.2	87
1890	....	....	8	65	27	....	100	7.7	− 92.3	− 22.6	− 77
1892	....	....	19	41	72	12	144	37.4	−106.6	7.1	− 33
1893	....	....	....	60	51	....	111	49.3	− 61.7	19.0	− 66
1897	....	....	3	41	64	....	108	6.8	−101.2	− 23.5	− 69
1898	....	....	16	98	104	12	230	48.6	−181.4	18.3	53
1899	....	....	26	98	....	15	139	53.1	− 85.9	22.8	− 38
1901	....	....	14	115	51	2	182	28.8	−153.2	− 1.5	5
1903	....	1	14	15	54	16	100	12.4	− 87.6	− 7.9	− 77
1904	....	....	15	52	69	17	153	53.6	− 99.4	23.3	− 24
1905	....	....	2	147	68	7	224	10.1	−213.9	− 20.2	47
1906	....	....	3	173	100	....	276	43.2	−232.8	12.9	99
1907	....	....	....	40	40	8	88	8.5	− 79.5	− 21.8	− 89
1908	....	....	8	155	98	14	275	3.4	−271.6	− 26.9	98
1909	....	....	21	71	96	3	191	4.0	−187.0	− 26.3	14
1910	....	30	28	156	114	3	331	....	−331.0	− 30.3	154
1911	....	....	12	107	40	....	159	178.7	19.7	148.4	− 18
1912	....	....	27	54	46	3	130	19.6	−110.4	− 11.7	− 47
Averages	0.1	4.1	13.4	85.9	67.2	8.5	177.0	30.3	−146.7	....	....

Months in which the temperature has not once reached 87° F. are indicated by leaders. All temperatures, differences, and departures are in Fahrenheit degrees. No signs appear before *plus* differences or departures. *Minus* differences indicate that Paris was cooler than Reno. Only years for which complete records for both places are available appear in the table. The values at bottom of table are the 19-year averages. The values for Paris are the Fahrenheit equivalents of the data in Table 2, p. 629, Monthly Weather Review, November, 1914.

Referring to the Reno-Paris table, the most noteworthy fact brought out is, that in 18 out of 19 years Reno's summers have been warmer than those of Paris. The exception was the summer of 1911, which, in Paris, was the hottest on record.

At Reno the greatest monthly excesses occur, as a rule, in July. The average seasonal excess is 177°, more than five times as large as that of Paris. For the 19 years covered by the records, the hottest summer was that of 1910, with an excess of 331°; the coolest, that of 1907, with an excess of only 88°. Eleven of the 19 summers were warmer than usual. No periodic alternation of warm and cool summers has been observable for periods of more than three years' duration.